

POPULATION STATUS AND CONSERVATION OF THE **BONELLI'S EAGLE** *Aquila fasciata* IN CYPRUS

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ABSTRACT.– Population status and conservation of the Bonelli's Eagle *Aquila fasciata* in Cyprus. The Bonelli's Eagle (BE) *Aquila fasciata* is currently the only eagle species breeding in Cyprus. About 75% of the nests are on large pine trees, and the rest are on cliffs. There are currently about 40 known breeding territories in the area under the effective control of the Government of the Republic of Cyprus and at least 10 more on the Turkish-occupied north Cyprus, hence the entire Cypriot BE population consist of about 50 pairs and it is probably the densest in the eastern Mediterranean basin (with an average of 5.4 pairs/1000 km²). An EU co-funded Project named LIFE BONELLI EASTMED is being implemented since September 2018 and will last until February 2023. This international project, with partners from Greece and Cyprus, aims at the conservation of the BE population in eastern Mediterranean. Under the framework of the project, there is an emphasis on identifying the threats to the population and addressing them with the appropriate conservation actions. Monitoring of the breeding sites revealed a nesting success that ranging 1.6 - 1.8 fledglings per successful pair in 2019-2021 (N = 35-38 active territories). Since 2019, 35 eagles (most of them juveniles) were fitted with GPS-GSM transmitters. None of these eagles have so far left the island so it can be said that the population is virtually non-migratory and eagles that fledge in Cyprus disperse within the island. There is also a clear discrimination between adult territorial occupancy, occurring mostly in the mountainous, rugged and forested areas of the island, while juveniles disperse to the lowlands, namely the coastal plains and the extensive central Mesaoria plain. Important foraging areas have been identified in parts of the UN-patrolled Buffer Zone. These areas are to a large extent devoid of human activities, and are rich in prey. During 2019-2021, 12 out of the 35 tagged eagles were found injured or dead. Direct persecution (shooting) was found as the most common risk factor (42% of the cases), electrocution, collision with wind turbines and secondary poisoning playing a minor but important role, impacting eagles' survival on the island.

RÉSUMÉ.– État de la population et conservation de l'Aigle de Bonelli *Aquila fasciata* à Chypre. L'Aigle de Bonelli (BE) *Aquila fasciata* est actuellement la seule espèce d'aigle se reproduisant à Chypre. Environ 75% des nids se trouvent sur de grands pins et le reste sur des falaises. Il existe actuellement environ 40 territoires de reproduction connus dans la zone sous le contrôle effectif du gouvernement de la République de Chypre et au moins 10 autres dans le Nord de Chypre occupé par la Turquie, d'où l'ensemble de la population chypriote d'Aigle de Bonelli composée d'environ 50 couples qui est probablement la plus dense du bassin méditerranéen oriental (avec une moyenne de 5,4 couples/1000 km²). Un projet cofinancé par l'UE nommé LIFE BONELLI EASTMED est mis en œuvre depuis septembre 2018 et durera jusqu'en février 2023. Ce projet international, avec des partenaires de Grèce et de Chypre, vise à la conservation de la population de l'Aigle de Bonelli en Méditerranée orientale. Dans le cadre du projet, l'accent est mis sur l'identification des menaces pesant sur la population et sur leur résolution par des actions de conservation appropriées. La surveillance des sites de reproduction a révélé un succès de nidification allant de 1,6 à 1,8 oisillons par couple ayant réussi en 2019 à 2021 (N = 35 à 38 territoires actifs). Depuis 2019, 35 aigles (la plupart juvéniles) ont été équipés d'émetteurs GPS-GSM. Aucun de ces aigles n'a jusqu'à présent quitté l'île, on peut donc dire que la population n'est pratiquement pas migratrice et que les aiglons qui s'envolent à Chypre se dispersent dans l'île. Il existe également une distinction claire entre l'occupation territoriale des adultes se produisant principalement dans les zones montagneuses, accidentées



et boisées de l'île, tandis que les juvéniles se dispersent dans les basses terres, à savoir les plaines côtières et la vaste plaine centrale de la Mésorée. D'importantes zones d'alimentation ont été identifiées dans certaines parties de la zone tampon patrouillée par l'ONU. Ces zones sont en grande partie dépourvues d'activités humaines, et sont riches en proies. De 2019 à 2021, 12 des 35 aigles marqués ont été retrouvés blessés ou morts. La persécution directe (tir) a été identifiée comme le facteur de risque le plus courant (42% des cas), l'électrocution, la collision avec des éoliennes et l'empoisonnement jouant un rôle secondaire mais néanmoins important, impactant la survie des aigles sur l'île.

Mots-clés: *Aquila fasciata*, Statut de la population, Conservation, Chypre.

Keywords: *Aquila fasciata*, Population status, Conservation, Cyprus.

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INTRODUCTION

Bonelli's Eagle (named thereafter BE) is a fairly large-sized eagle, typical of Mediterranean landscapes of southern Europe and western Asia. It is considered an important top avian predator in the food-chain of Mediterranean ecosystems (CHEYLAN 1977; DONAZAR *et al.*, 2005) and as such, it can also be regarded as a flagship species for their conservation. Raptors around the world are facing challenges due to anthropogenic activities which often have negative impacts on their populations, driving some of them to the verge of extinction. Poisoning, poaching, electrocution and collision with power-lines and wind turbines have been identified as the major causes of raptor mortality (MACIOROWSKI *et al.*, 2020).

The BE is no different in this respect. During the last decades, the species suffer from local declines and range restriction in Europe, resulting in the declaration of it as having an unfavorable conservation status (SPEC 3) (BIRDLIFE INTERNATIONAL, 2004). Its European population is estimated at 1032-1223 pairs, 80% of which is in the Iberian Peninsula (BIRDLIFE INTERNATIONAL, 2010).

The BE is the only eagle species that breeds in Cyprus since the extinction of the Imperial Eagle, *Aquila heliaca*, in the 1980s (KOURTELLARIDES, 1998). Another change in the island's raptor avifauna is the settling of the Long-legged Buzzard, *Buteo rufinus*, which has started to nest in Cyprus in the early 1990s and is currently a common breeder.

The two species share some areas for nesting and foraging, but it is believed that there is no fierce competition between them as the eagle is a predominantly tree nester and avian predator and the buzzard a cliff-nester and small mammal predator (KASSINIS *et al.*, 2022).

The BE population has known some significant fluctuations since the middle of the 20th century. During the late 1950s the species was considered common, with a population estimate of more than 50 pairs (FLINT & STEWARD, 1992). However, this estimate was based largely on anecdotal observations. During the 1980s and early 1990s, the population declined to less than 20 pairs (BIRDLIFE INTERNATIONAL / EBCC 2000) most probably due to extensive use of poison baits to control Red Fox *Vulpes vulpes* population, but this figure as well, was not based on systematic monitoring but mostly on expert opinion.

The first study that was based on systematic surveys (KASSINIS, 2010) estimated the BE population at 31 - 39 breeding pairs (0.52 - 0.65 pairs / 100km²) in the area controlled by the Cyprus government. The population in the Turkish-occupied part of the island is estimated at about 10 pairs (BEDON *et al.*, 2013), with no details on nest locations and breeding success.

KASSINIS (2010) reported that the majority of the nests (near 70%) are built on large Calabrian pine *Pinus brutia* trees. Other nests are built on remote and extensive cliff formations or deep, high-walled ravines.

The average altitude of the nests was 625 + 257m a.s.l (N = 22), but it varied substantially

from a minimum of 55m up to a 1,200m a.s.l., suggesting that the eagles can potentially occupy most of the island. Nearest neighbor distance (NND) for 27 nesting sites was 7.4 + 1.1km (range 4.1 - 11.5km). The mean number of fledglings / successful pair was 1.44 + 0.53 for the period 1999-2009 (KASSINIS, 2010).

The species inhabits mountainous, rugged terrain, nests mostly at the forest edge but usually hunts in more open areas. Immature eagles during dispersal tend to hunt in lowland maquis, agricultural areas and wetlands where prey is more abundant and more easily obtainable. Also, a few, mostly juvenile and immature birds appear annually in coastal areas during fall.

The BE in Cyprus preys mainly on medium-sized birds and small mammals (IEZEKIEL *et al.*, 2004; KASSINIS, 2010). Its main prey species are the Chukar Partridge *Alectoris chukar*, Common Woodpigeon *Columba palumbus*, Rock and feral pigeon *C. livia*, Corvids (mainly Black-billed Magpie *Pica pica* and Hooded Crow *Corvus corone cornix*), water birds found near wetlands and reservoirs (Coot *Fulica atra* and Little Egret *Egretta garzetta*) and domestic fowl. Game farm chukars released in late summer for augmenting the wild stock for hunting purposes are utilized by the eagles that regularly hunt in the vicinity of the release pens in the countryside (KASSINIS & MILTIADOU, 2010). Small mammals, mainly the abundant Black Rat *Rattus rattus* but also the European Hare *Lepus europaeus* come second. Reptiles follow in importance, especially large lizards such as the Starred Agama *Stellagama stellio*, occasionally Schneider's Skink *Eumeces schneiderii*. In 2009, the remains of a Cyprus mouflon lamb *Ovis gmelini ophion* were found under a BE's nesting tree. The mouflon is the largest mammal on the island and is quite common in the eagle's stronghold, Pafos forest.

MATERIALS AND METHODS

The Life Project "Conservation and Management of the BE population in eastern Mediterranean" (Life Bonelli EASTMED) is being implemented from September 2018 to February 2023 (4.5 years duration). Its major objective is to ensure a favorable conservation status for the species' populations in the Eastern Mediterranean basin. Project partners are from Greece and Cyprus with the University of Crete as the coordinating beneficiary. Other partners include the Greek Ministry of Environment, the Hellenic Ornithological Society, NCC (Nature Conservation Consultants Ltd), the Cyprus Game and Fauna Service and the Cyprus Department of Forests. Several preparatory and conservation actions are implemented during the project:

- Standard monitoring of territories and nesting activity,
- Telemetry study aims at collecting movement data and identify risk factors (tagged as nestlings before fledging or trapped),
- Data collection on the main prey species,
- Reducing disturbances near nesting sites,
- Reduce eagle mortality from interactions with electricity infrastructures,
- Prevent eagle drowning in artificial reservoirs
- Improve the foraging habitat of the eagles (seeding plots, create forest clearings).

RESULTS

Main Project Actions

Monitoring of territories and nesting activity.— Monitoring has been carried out for 2019, 2020 and 2021 nesting seasons (TAB I).

Nesting activity, territorial behavior and aerial displays were noted from early December. Egg-laying start in the lower altitudes territories

Nesting season	Active territories	Successful nests monitored	Mean fledglings / successful pair
2019	37	17	1.6
2020	35	21	1.8
2021	38	21	1.8

TABLEAU I.— Nesting sites monitoring results.
Résultats de la surveillance des sites de nidification.

in mid-January and continue throughout February. Eaglets fledge mostly during May, and some in June. By the end of August most juveniles are in dispersal mode. BE usually have an average mature age of 3,5 years (BALBONTIN *et al.*, 2003), although some tagged eagles were observed pairing up on their second year, but no successful nesting has been recorded at these ages.

Most of the nesting pairs had 1-2 nestlings per brood, and 3 nestlings were recorded only twice in 20 years of monitoring (last time in 2020).

In 2021, 24 pairs (63%) of the 38 nesting territories monitored, had only tree nests in their territory, 9 pairs occupied cliff nests (about 24%) whereas 5 pairs had both a tree and a cliff nest (13%). The average number of alternative nesting trees per nesting site was 2.6 (range 1-7) for the exclusive tree-nesters.

Tagging eagles with GPS transmitters. – In the period 2019-2021, 35 Bonelli's Eagles were fitted with GPS/GSM data loggers (Ornitela 30g).

- In 2019 18 birds were tagged (13 juveniles, 4 subadults, 1 adult).
- In 2020 9 birds (8 juveniles, 1 adult).
- In 2021 8 birds (7 juveniles, 1 adult).

The above tagged birds were either tagged as nestlings before fledging or when trapped post-fledging. From 2019 to 2021, 19 birds were tagged as nestlings, 14 were trapped and tagged and two were birds that recovered from the Game and Fauna Service Wildlife Rehabilitation Center and released (one of them was rescued after being caught in a chicken pen and another was found weak within a windfarm after probably colliding with the wind turbine).

Out of 14 birds that were trapped and tagged, two were adults (2 females) and two subadults (1 female, 1 male). The other ten were all 1st calendar year juveniles (8 females, 2 males). Overall, 11 out of 14 BE that were trapped and tagged were females.

Annual movements

The first-year movements of two Juvenile BE at dispersal are shown (FIG. 1 and FIG. 2). By end of August all juveniles are in dispersal mode. Most commonly, juveniles are using the low-lying areas, with the Mesaoria plain and Larnaka district lowlands being used more often. Wetlands such as salt lakes, dams and reservoirs, sewage treatment plans and perennial streams are often visited by dispersing juveniles.

FIG. 1.– First year movements during dispersal of a GPS-tagged juvenile Bonelli's Eagle.

Mouvements enregistrés par GPS lors de la première année de la dispersion d'un Aigle de Bonelli juvénile.

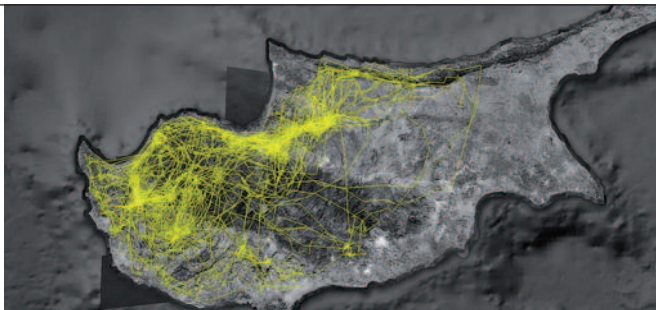
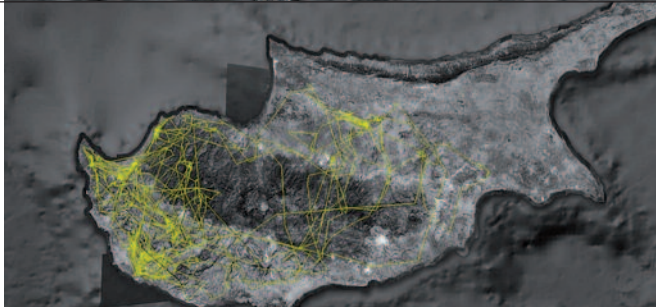


FIG. 2.– First year movements during dispersal of a GPS-tagged juvenile Bonelli's Eagle.

Mouvements enregistrés par GPS lors de la première année de la dispersion d'un Aigle de Bonelli juvénile.



The annual movements of two adult female Bonelli's Eagles are shown in their respective, adjacent territories (FIG. 3).

Sensitivity maps (FIGS. 4, 5) were developed using the Maxent model for juveniles and adults, by analyzing telemetry data from the first year of the project (2019) and incorporating the information obtained from studying nesting distribution and success for almost 30 years.

When becoming subadults BE tend to use more canyons and gorges that are not occupied by an adult pair especially in the districts of Limassol and Paphos. Use of lowlands is still observed but for short periods.

Identifying main prey items

Pellets and prey remain have been collected in May-June during the nesting seasons of 2019, 2020 and 2021 from several sites across the island. In total 238 pellets and prey remain from 25 sites have been collected and analyzed, representing 364 prey items. Similarly, this has been carried out in Project's nesting sites in Crete, Aegean islands, and parts of the mainland from the Greek partners. Some preliminary results for Cyprus showed that as of % frequency of occurrence (%FO) 49% were birds, 47% mammals and 4% reptiles. As far as % Biomass 52% were birds, 46% mammals and 2% reptiles (H. ALIVIZATOS, Natural History Museum of Crete, pers. com.).

FIG. 3.– Territories of two tagged female Bonelli's Eagles.

Territoires de deux femelles Aigles de Bonelli marquées.

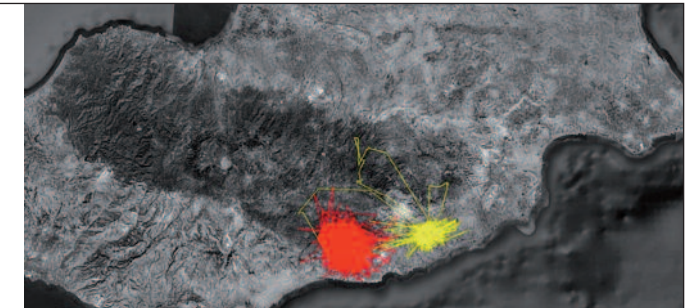


FIG. 4.– Sensitivity map of juvenile in dispersal mode.

Carte prédictive de la dispersion des juvéniles.

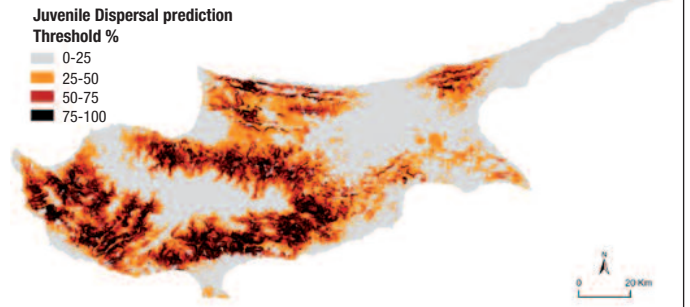
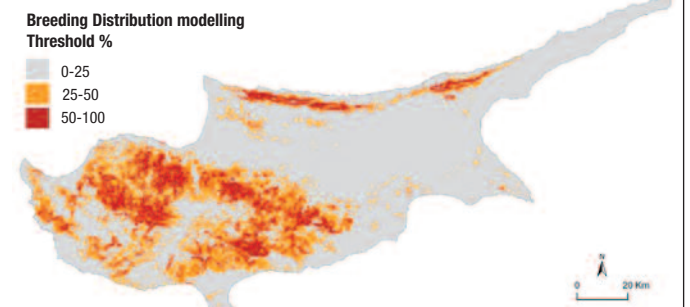


FIG. 5.– Sensitivity map of Breeding distribution.

Carte de la modélisation de la répartition de l'aire de reproduction.



Reducing disturbance near nesting sites

By the end of the project, access by public on roads near sensitive nesting areas will be controlled. A gate will be used that will be blocking access during the breeding season. The biggest obstacle to apply the specific action is that in the lowlands and outside the state forest areas, most of the land is privately owned and blocking access will create conflicts on land use. As of this, the budget for the specific action will be carried out mostly in state forest areas after collaboration with the Department of Forests in order to choose appropriate locations. Most of the candidate locations have already been identified.

Reducing mortality from electrical infrastructures

After analyzing telemetry data from the first year of the project (2019) and incorporating the information obtained from studying nesting distribution and success for almost 30 years, a sensitivity map of the species for the entire island was developed using a Maxent model. MAXENT (Maximum entropy model) is a species distribution model (SDM) commonly used in ecological studies for predicting species' distribution by utilizing all kind of environmental data and a set of the species' presence records (FOURCADE *et al.*, 2014). The sensitivity map was then used in a GIS program in order to select dangerous electricity poles and retrofit them. Two areas were chosen for retrofitting at a first stage, with a total of 30 electricity poles identified.

Reducing eagle mortality in artificial reservoirs

Drowning in small reservoirs with steep banks and cemented water tanks is a serious mortality issue for wildlife in general, especially in arid areas with little surface water available in the long dry season (ANDERSON *et al.*, 1999; LAFON, 2006). Cyprus being an arid island, the construction and use of water reservoirs used to be very common, in order to water livestock and summer crops. Many such water storage tanks have been abandoned across the island but are still getting filled with water during the winter and pose a potential threat to wildlife. For this reason, an action towards minimizing this risk

in areas with previous raptor and other wildlife drowning records was implemented. 44 floating rafts have been installed in small reservoirs and large water tanks in such areas and within areas frequently used by BE and other large raptors. It is under consideration to make it mandatory under the law for the owner to take prevention measures for wildlife drowning in such reservoirs, at least within SPAs and Natura 2000 sites.

Improving Bonelli's Eagles foraging habitat

For the purposes of this action, several fields and potential openings to be cleared have been identified in three Natura 2000 project sites. In total, 200.1 decares (20 hectares) have been opened by clearing scrub vegetation, cultivated and sown with winter cereals in 2020 and 2021. In April-May food plots have been checked for crop growth. These food plots/clearings are expected to attract wildlife that is important for these areas (chukars, woodpigeons, hares, mouflon and smaller species of birds, mammals and reptiles), some of which are important in BE eagle diet (such as partridges, pigeons, rodents). In addition to this, approximately another 4,500 decares (450 hectares) are planted with legume/cereal mixture island wide for wildlife habitat management, improvement mainly for hare, chukars, woodpigeons, turtle doves as well as for the protected Cyprus mouflon. A large portion of these food plots are within BE eagle territories which are positively affected by this habitat management practice that creates foraging areas for the species.

Identifying threats and causes of mortality from tagged eagles

In the period 2019-2021, 11 out of 35 BE tagged with GPS loggers were found dead or injured. In addition, 3 unmarked eagles were found dead, and one was shot, recovered rehabilitated and released. Causes of death or injury were the following:

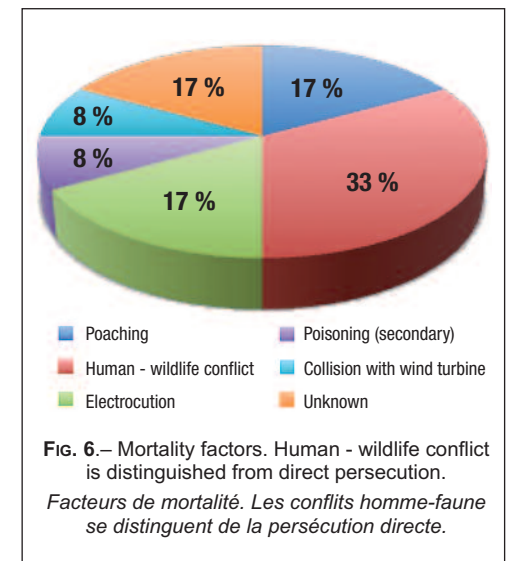
■ **Poaching/shooting:** 7. Two eagles were shot during hunting days from poachers. Five BE were shot near poultry pens. Two tagged birds, two untagged and another tagged that was taken to the Game and Fauna rehabilitation center, recovered and released.

TABLEAU II.— Risk and mortality factors that were documented during 2019-2021.
Facteurs de risque et de mortalité qui ont été documentés au cours de la période 2019-2021.

Risk factor	Tagged eagles	Unmarked eagles	Total	Remarks
Direct persecution	5	2	7	2 untagged birds found shot on non-hunting days near poultry pens. Another tagged eagle was shot near a farm and recovered
Poisoning	2		2	One deliberate poisoning targeting the eagle that was preying on poultry, one secondary poisoning from a poisoned rodent.
Electrocution	2	1	3	
Collision with wind turbines	1		1	Another unmarked eagle was found injured in a wind farm and recovered
Unknown reason	2		2	
Total	9	3	15	

- **Poisoning:** 2. One deliberate targeting the eagle that was preying on poultry, one secondary poisoning from consuming a rodent that consumed rodenticide (bromadiolone),
- **Electrocution/collision with utility lines and wind turbines:** 4. Two tagged and one untagged BE died from electrocution, and one was killed by colliding on a wind turbine,
- **Unknown/unspecified reasons/tagged eagle could not be recovered:** 2.

The mortality events that were documented during 2019 - 2021 (TAB. II) show that the main threat to the species in Cyprus is direct persecution (shooting and poisoning). Two out of 5 incidents occurred during hunting days, so they may result from incidental interaction between the hunter and the eagle, while the other 3 occurred on non-hunting days as a result of deliberate shooting from farm owners that raise animals such as chickens and rabbits that are sometimes eaten by the eagles. Although previously it was mentioned that two more non-tagged birds were recovered shot, in order to have a better and more correct understanding of the impact of every mortality cause, only the tagged birds that died were taken into account to better understand the magnitude of every type of mortality. Furthermore, the tagged bird that was shot and recovered near a poultry farm was considered as a loss due to direct persecution because of causing damage to humans. Considering the above, 6 out of 12 cases or



50%, the birds died from direct persecution. For the 4 (3 shot and one poisoned) out of 12 birds or 33.3%, were killed (or attempted killing - one case) deliberately, the suspected reason was the eagle damage to domesticated animals such as chickens and rabbits. Bearing in mind the above and since that the biggest threat of BE is deliberate killing near domesticated animal pens, Human - wildlife conflict should be differentiated (FIG. 6) from the other mortality factors for better understanding the magnitude of the problem, but help us find solutions to it as well.

Poaching and loss of birds during hunting season on hunting days, was the cause of death for two birds or 17%, same as electrocution. Since the project started, one tagged bird was confirmed to die because of secondary poisoning from rodenticides (bromadiolone) and another bird is suspected for secondary poisoning (waiting toxicological test result). Mortality data also revealed a previously unknown risk from electrocution, when 2 tagged and 1 non-tagged eagles were found dead. Apparently, there is a need for further retrofitting of powerlines, an issue that is being discussed with the Cypriot Electricity Authority. Also, the first case of eagle dying from collision with a wind turbine has been documented.

DISCUSSION

The BE population in Cyprus is in a good conservation status and being closely monitored. The implementation of the LIFE BONELLI'S EASTMED project intensified and increased this

long-term effort. Nesting site monitoring and eagle marking and tagging will continue in the near future. The deployment of GPS/GSM data-loggers on a large number of eagles (35 by September 2021) provides valuable information for the species conservation. New territories have been identified from tagged individuals, causes of mortality were promptly identified and important foraging areas identified. Also, potentially dangerous utility networks were mapped, so mitigation measures would hopefully be applied in the coming years. Important information coming from eagle-trapping was also retrieved. The majority of trapped individuals were females. This could have been the case since results from telemetry revealed that females are wondering greater distances than males, making it more likely for them to encounter a trap. Another possible explanation could be that it is harder for the (bigger) females to catch fast prey such as pigeons and wild chukars than for (smaller and more agile) males, resulting in being more attracted to recently



FIG. 7.— The body of a juvenile Bonelli's Eagle that was recovered after a collision with a wind turbine. *Cadavre d'un Aigle de Bonelli juvénile après collision avec une éolienne.*

released partridges. The significant larger size of the female may also suggest larger demand for prey. Tracking of tagged eagles, also showed that certain spots within some of the foraging areas have been observed to be used every year by juveniles during their dispersal. At the end of the fall and the beginning of winter, some of the juveniles are utilizing the United Nations-administered "Buffer zone" (Strip between the area that is under the effective control of the Republic of Cyprus and the Turkish-occupied north part of the island). This is especially true for the area west of the City of Nicosia all the way west along the plains at the foothills of Troodos mountains. This can be partly explained as the main hunting season starts around that time and the "Buffer zone" acts as a wildlife sanctuary, where many species take refuge (it is a non-hunting zone). At the same time winter cereal crops are sowed in that area, attracting large flocks of feral pigeons and woodpigeons seeking food and refuge from the hunting activities that are taking place in all the other parts of the island. The use of this area has not been observed in such an extent with tagged subadults that are still wondering without a territory. It is known and documented by studies of other bird species, that movements performed by juveniles are completely different from territorial adults (BALBONTIN & FERRER, 2009). When the nesting season starts and while still in subadult stage, most of the BE stay in Paphos district. Paphos is the district that has been affected the least from the abandonment of traditional agricultural practices. As a result, it is abundant in prey species for the BE such as woodpigeons and chukar partridges. Furthermore, Paphos district has larger areas under Natura 2000 and SPA protection status compared to the rest of the island. Another reason is the district's intense topography having many streams coming from high elevations towards the sea and creating gorges and valleys suitable for the species.

Cyprus has a mean road density of 2.3km/km² that is comparable with countries like France, Italy and Spain, many times the island's size and population. The road network on the island has increased by 88% in the last 30 years and is also dense within the NATURA

2000 Network (ZOMENI & VOGIATZAKIS, 2014). Dense road network fragments habitats and increases pressures on species as well (HEILMAN *et al.*, 2002). In addition to this reality, management practices like the dense firebreak network across the island's mountains further fragments habitats and increases disturbance. Maintaining and widening forest roads during the nesting season along with off-road driving in such areas, could be a factor that can increase disturbance and may lead to nest failure as was the case in some occasions. On the other hand, fire prevention is a major effort annually on the island, due to the prolonged dry season. Wildfires destroy large areas every year and, in many cases, nesting territories have been affected. The BE in Cyprus is mostly a tree-nester and fires destroying such large trees can degrade nesting habitat irreversibly.

Summing up the telemetry results, it is obvious that human activities are negatively affecting the population of the BE in Cyprus. The differentiated factor "Human-wildlife conflict" after the telemetry results it has proven to be the single most important mortality factor for the species. In addition, secondary poisoning, another anthropogenic factor was marked as another source of mortality. Over 200 metric tons of rodenticide containing Bromadiolone are distributed on average (2008-2019) every year by the Department of Agriculture in Cyprus. The bait is composed by crushed cereal seeds (mainly barley) mixed with carob powder that rats consume and other species as well, are attracted to, coated with Bromadiolone. Furthermore, and without a doubt, the fact that the species is nesting mostly on trees is one of the reasons that the population in Cyprus is in a better state compared to other Mediterranean Countries. Using pine trees for nesting enable a denser breeding as opposed to populations that nest exclusively on cliffs. Having more territories and nesting pairs helps the population replenish losses easier. Although, in a fast-changing environment, in a country with very limited space, the anthropogenic impacts are expected to negatively affect the survival of the species even more. Fire intensity and frequency have been rising rapidly, destroying forested areas and nesting habitat for the

BE, can be considered worrisome for the future of the BE breeding range over the island. Unfortunately, this will worsen in the future as the temperature is expected to rise.

BIBLIOGRAPHY - WEBOGRAPHY

- ANDERSON (M.D.), MARITZ (A.W.A.) & OOSTHUYSEN (E.) 1999.– Raptors drowning in farm reservoirs in South Africa. *Ostrich*, 70: 139-144.
- BALBONTIN (J.), PENTERIANI (V.) & FERRER (M.) 2003.– Variations in the age of mates as an early warning signal of changes in population trends? The case of Bonelli's Eagle in Andalusia. *Biological Conservation*, 109: 417-423.
- BETON (D.), SNAPE (R.) & SAYDAM (B.) 2013.– Status and ecology of the Bonelli's Eagle, *Aquila fasciatus*, in the Pentadaktylos Mountain Range, Cyprus (*Aves: Falconiformes*). *Zoology in the Middle East*, 59: 123-130.
- BIRDLIFE INTERNATIONAL / EUROPEAN BIRD CENSUS COUNCIL, 2000.– *European bird populations: estimates and trends*. Cambridge, UK: BirdLife International (BirdLife Conservation Series No. 10).
- BIRDLIFE INTERNATIONAL, 2004.– *Birds in Europe: population estimates, trends and conservation status*. Cambridge, UK: BirdLife International (BirdLife Conservation Series No. 12).
- BIRDLIFE INTERNATIONAL, 2010.– *Review of the implementation of species action plans for threatened birds in the European Union. Final Report (2011)*. *Species Accounts produced in 2010: Bonelli's Eagle*.
- CHEYLAN (G.) 1977.– La place trophique de l'Aigle de Bonelli *Hieraaetus fasciatus* dans les biocénoses Méditerranéennes. *Alauda*, 45: 1-17.
- CRAMP (S.) & SIMMONS (K.L.) 1980.– *The birds of the western Palearctic, vol. II*. Oxford University Press, Oxford.
- DONAZAR (L.), GANGOSO (M.), FORERO (G.) & JUSTE (J.) 2005.– Presence, richness and extinction of birds of prey in the Mediterranean and Macaronesian islands. *Journal of Biogeography*, 32: 1701-1713.
- FLINT (P.) & STEWART (P.) 1992.– *The birds of Cyprus*. Second edition. British Ornithologists Union. U.K.
- FOURCADE (Y.), ENGLER (J.O.), RÖDDER (D.) & SECONDINI (J.) 2014.– Mapping Species Distributions with MAXENT. Using a Geographically Biased Sample of Presence Data: A Performance Assessment of Methods for Correcting Sampling Bias. *PLoS ONE* 9(5): e97122. <https://doi.org/10.1371/journal.pone.0097122>
- HEILMAN (G.E.), STRITTHOLT (J.R.), SLOSSER (N.C.) & DELASSALA (D.A.) 2002.– Forest fragmentation of the conterminous United States: assessing forest intactness through road density and spatial characteristics. *Bioscience*, 52: 411-422.
- IEZEKIEL (S.), BAKALOUDES (D.E.) & VLACHOS (C.G.) 2004.– The diet of Bonelli's Eagle *Hieraaetus fasciatus* in Cyprus. In: CHANCELLOR (R.D.) & MEYBURG (B.-U.) (eds.). *2004 Raptors Worldwide*. WWGBP/MME.
- JAVIER (B.) & FERRER (M.) 2009.– Movements of juvenile Bonelli's Eagles *Aquila fasciata* during dispersal. *Bird Study*, 56: 86-95.
- KASSINIS (N.) 2009.– Long-legged Buzzard *Buteo rufinus rufinus* breeding distribution and abundance in Cyprus. *Avocetta*, 33: 75-78.
- KASSINIS (N.) 2010.– Demographics of the Bonelli's Eagle *Aquila fasciata* population in Cyprus. *Bird Census News*, 23: 21-27.
- KASSINIS (N.), TZIRKALLI (E.), MILTIADOU (M.), MOYSI (M.), CHARALAMBIDOU (I.), ROULIN (A.) & VOGIATZAKIS (I.N.) 2022.– Feeding Ecology of the Long-Legged Buzzard and Diet Overlap with Sympatric Bonelli's Eagle on Cyprus. *Journal of Raptor Research*. <https://doi.org/10.3356/JRR-21-34>
- KASSINIS (N.) & MAMMIDES (C.) 2016.– Winter bird surveys in Cyprus, 2007-2016. Analysis of the population trends. *Bird Census News*, 2015, 29/1-2: 37-45.
- KASSINIS (N.) & MILTIADOU (M.) 2010.– Bonelli's Eagle status and conservation in Cyprus. In: *The Bonelli's Eagle Ecology, behaviour and conservation* (editor V.J. HERNÁNDEZ). Tundra Publishing, Spain. In Spanish.
- KOURTELLARIDES (L.) 1998.– *Breeding birds of Cyprus*. Bank of Cyprus group, Cyprus.
- LAFON (A.) 2006.– Installation of devices in water tanks to prevent drowning of wild animals. In: BASURTO (X.), HADLEY (D.), eds. 2006.– *Grasslands ecosystems, endangered species, and sustainable ranching in the Mexico-U.S. borderlands*. Conference proceedings. RMRS-P-40. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 106-110.
- MACIOROWSKI (G.), ZDUNIAK (P.), BOCHENSKI (M.), URBANSKA (M.), KROL (P.) & POLAKOWSKI (M.) 2021.– Breeding habitats and long-term population numbers of two sympatric raptors - Red Kite *Milvus milvus* and Black Kite *Milvus migrans* - in the mosaic-like landscape of western Poland. *Journal of Ornithology*, 162: 125-134.
- ZOMENI (M.) & VOGIATZAKIS (I.N.) 2014.– Roads and Roadless Areas in Cyprus: Implications for The Natura 2000 Network. *Journal of Landscape Ecology*, 7: 75-90.

CAUSES OF MORTALITY FOR BONELLI'S EAGLE IN CYPRUS, 1996-2021: SPATIAL AND TEMPORAL PATTERNS

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ABSTRACT.– Causes of mortality for Bonelli's Eagle in Cyprus, 1996-2021: Spatial and temporal patterns. The Bonelli's Eagle *Aquila fasciata* is the only eagle species that breeds on the island of Cyprus. From 1996 to September 2021, 64 Bonelli's Eagles were found injured or dead and were brought for treatment/post-mortem examination. Cause of injury/death was mostly shooting (47%) and poisoning (23%), collision with powerlines/structures and electrocution (14%), trapping on limesticks (2%) and 15% unknown and/or unspecified. More than a third of these cases were in Pafos district (the westernmost district), whereas Larnaca and Nicosia were 25% and 22% respectively, with Limassol involving 14% of them. Three cases involved GPS-tagged birds dying in the Turkish-occupied northern part of the island. Shooting occurred mostly during the November-February period (major hunting season) (87%). On the other hand, poisoning occurred mostly from January - May (67%) with the rest occurring from September-December. Almost half of the cases involved juveniles (43%), a third involved adults (34%) and the rest (23%) were immatures. Most common cause of injury/death for juveniles was shooting (39%) and poisoning (26%), whereas poisoning was the primary cause of death (42%) for immature eagles with collisions and electrocutions coming 2nd (34%). Adults suffered mostly from shooting with 72% of cases, whereas the rest was due to poisoning. Sixteen cases of dead individuals involved tagged birds; in the period 2002-2009, 4 out of 14 eagles tagged with VHF transmitters were found dead due to shooting (75%) and poisoning. In the period 2019 -2021, 12 out of 35 Bonelli's Eagles tagged with GPS/GSM loggers, as part of the international project LIFE BONELLIS EASTMED, were found dead or injured. Shooting was involved in 42% of cases, whereas for the first time electrocution (2 cases) and collision in wind farms (1 case) were documented. Poisoning involved 2 cases, one was a case of secondary poisoning with rat poison (bromadiolone), the first reported on the island involving a large raptor.

RÉSUMÉ.– Causes de mortalité de l'Aigle de Bonelli à Chypre, 1996-2021 : modèles spatiaux et temporels. L'Aigle de Bonelli *Aquila fasciata* est la seule espèce d'aigle qui se reproduit sur l'île de Chypre. De 1996 à septembre 2021, 64 aigles ont été retrouvés blessés ou morts et amenés pour traitement/autopsie. La cause des blessures/décès était principalement par balle (47 %) et empoisonnement (23 %), collision avec des lignes électriques/structures et électrocution (14 %), piégeage (2 %) et 15 % inconnue et/ou non précisée. Plus d'un tiers de ces cas se trouvaient dans le district de Pafos (le district le plus à l'Ouest), tandis que Larnaca et Nicosie étaient respectivement de 25 % et 22 %, Limassol impliquant 14 % d'entre eux. Trois cas concernaient des oiseaux marqués par GPS mourant dans la partie nord de l'île occupée par la Turquie. Le tir a eu lieu principalement en novembre-février (grande saison de chasse) (87 %). D'autre part, les empoisonnements se sont surtout produits de janvier à mai (67 %), puis de septembre à décembre. Près de la moitié des cas concernaient des jeunes (43 %), un tiers concernait des adultes (34 %) et le reste (23 %) était des immatures. La cause la plus fréquente de blessures/de décès chez les juvéniles était le tir (39 %) et l'empoisonnement (26 %), tandis que l'empoisonnement était la principale cause de décès (42 %) pour les immatures, les collisions et les électrocutions venant en deuxième position (34 %). Les adultes ont été victimes surtout de tirs avec 72 % des cas, le reste étant dû à des empoisonnements. Seize morts concernaient des oiseaux marqués; durant la période 2002-2009, 4 aigles sur 14 munis d'émetteurs VHF ont été retrouvés morts suite à des tirs (75 %) et à des empoisonnements. Au cours de la période 2019 -2021, 12 des 35 aigles munis d'enregistreurs GPS/GSM, dans le cadre du projet international LIFE BONELLIS EASTMED, ont été retrouvés morts ou blessés. Des tirs ont été impliqués dans 42 % des cas, alors que pour la première fois une électrocution